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Effect of Precooling on

Market Quality of

CRANBERRIES

Shipped by Rail or Truck

Marketing Research Report No. 287

U. S. DEPARTMENT OF AGRICULTURE

Marketing Research Division

Agricultural Marketing Service

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EFFECT OF PRECOOLING ON MARKET QUALITY OF CRANBERRIES SHIPPED BY RAIL OR TRUCK

By J. Kaufman, S. M. Ringel, A. A. Hamer,
E. P. Atrops, and G. B. Ramsey¹
Biological Sciences Branch
Agricultural Marketing Service

SUMMARY

Prepackaged Massachusetts-grown cranberries in master cartons and nonscreened (in the chaff) berries in field boxes were precooled in mechanically refrigerated railway cars and trucks used as simulated cold-storage rooms. Temperatures of 45° F. or lower were obtained in most cases after 24 hours of precooling, and in nearly all tests temperatures of 40° or lower were obtained after 48 hours of precooling.

Shipping tests were conducted in 2 pairs of cars and in 1 pair of trucks to compare the effects of precooling and of nonprecooling on transit temperatures, decay, and keeping quality. From 2 to 11 days were required for the temperatures of the berries in the nonprecooled rail loads to drop to the initial temperatures in similar locations within the precooled loads. The precooled loads (rail and truck) averaged 6 to 12 degrees cooler than the nonprecooled loads for the trip as a whole.

Freshly harvested, precooled cranberries developed less decay in transit than nonprecooled berries. When the cranberries were held 3 to 4 weeks in common storage before sorting, packaging, and shipping during cool weather, development of decay was about the same in precooled and nonprecooled berries, both in transit and afterward. The results indicate that, during warm weather, precooling of freshly harvested, prepackaged cranberries packed in master cartons may reduce decay in transit, particularly in long-distance shipments, and during subsequent marketing.

INTRODUCTION

It is well known that cranberries keep best at low temperatures (36°-40° F).² Previous studies have shown, however, that tight loads of warm (nonprecooled), prepackaged cranberries packed in master cartons cool slowly in transit, especially in the middle layer of the loads.³

In view of these findings, further tests were conducted in 1957 with the following objectives:

- (1) To determine the practicability of cooling cranberries before shipment,
- (2) to compare transit temperatures of precooled and nonprecooled packaged cranberries packed in master cartons, and

¹ Mr. Kaufman and Mr. Ringel are pathologists, Mr. Hamer is an engineering aide, Mr. Atrops a physiologist, and Mr. Ramsey a principal pathologist.

² Wright, R. C., Rose, D. H., and Whiteman, T. M. The commercial storage of fruits, vegetables, and florist and nursery stocks. U. S. Dept. Agr., Agr. Mktg. Serv., Handbook No. 66. 1954.

³ Hruschka, H. W., Kaufman, J., Redit, W. H., Ramsey, G. B., and Harvey, E. M. Effects of precooling, salting, carton ventilation, and load pattern on temperature, moisture condensation, and spoilage in rail shipments of prepackaged Early Black Massachusetts-grown cranberries. U. S. Dept. Agr., Agr. Mktg. Serv., AMS-43. 1955 (processed).

Kaufman, J., Benfield, P. L., and Harding, P. R., Jr. Shipping tests with Massachusetts-grown cranberries in conventional refrigerator cars with standard ventilation and in mechanically refrigerated cars. U. S. Dept. Agr., Agr. Mktg. Serv., AMS-187. 1955 (processed).

(3) to determine the effect of precooling on development of decay and on keeping quality.

This study is part of a continuing program of research designed to reduce the cost of marketing farm products.

PROCEDURE

Preshipment cooling. --Because no cold-storage rooms were available in the Cape Cod, Mass., area, cold-storage conditions were simulated in mechanically refrigerated cars or trucks. To provide cold-air circulation around vented fiberboard cartons, the master cartons were stacked to provide a 2- to 6-inch space around their sides and ends and a 6- to 11-inch space at the side walls of the car or truck. Because of the air spaces, two cars or trucks were necessary to precool a single load.

Temperatures were taken in the top, middle, and bottom layers of the stacks by means of thermocouples inserted about 3 inches deep in the 1-pound packages of cranberries and about 6 inches deep in the field boxes. At the completion of the precooling period, the cartons from 2 cars used for precooling were combined to make 1 full load for a precooled rail shipment. Similarly, cranberries from 2 trucks used in precooling were loaded into 1 truck for shipment after precooling.

Shipping Tests. --Tests were conducted in mechanically refrigerated cars and trucks during September and October, 1957. The loading and shipping data are summarized in table 1. Two pairs of cars were shipped from Massachusetts to Los Angeles (tests 1 and 2) and a pair of trucks was shipped to Chicago (test 3). One car and one truck of each pair contained precooled fruit, and one of each was loaded with nonprecooled fruit.

TABLE 1.--Loading and shipping data of 4 rail and 2 truck shipping tests of cranberries, September-October 1957

Test and treatment	Inside dimensions of cars and trucks			Destination	Routing	Date loaded	Date unloaded	Number of master cartons per load ¹
	Length	Width	Height					
1. Rail cars:								
E (precooled)-----	44'-5"	8'-8"	7'-10"	Los Angeles	N.H., Penn, C.B. & Q., U.P., S.P.	9/18/57	² 10/2/57	1,132
F (nonprecooled)-----	44'-5"	8'-8"	7'-10"	Los Angeles	N.H., Penn, C.B. & Q., U.P., S.P.	9/19/57	10/3/57	1,132
2. Rail cars:								
G (precooled)-----	44'-5"	8'-8"	7'-10"	Los Angeles	N.H., Erie, A.T. & S.F.	10/9/57	10/21/57	1,132
H (nonprecooled)-----	44'-5"	8'-8"	7'-10"	Los Angeles	N.H., Erie, A.T. & S.F.	10/9/57	10/21/57	1,132
3. Trucks:								
C (nonprecooled)-----	33'-10"	7'-3"	7'-3"	Chicago	Via N.Y. thruway, Ohio Turnpike, Indiana Turnpike.	9/19/57	² 9/20/57	1,000
D (precooled)-----	34'-4"	7'-5"	7'-3"	Chicago	Via N.Y. thruway, Ohio Turnpike, Indiana Turnpike.	9/19/57	9/23/57	1,000

¹ Test packages not included in the number of packages per car or truck; most of the cartons in the cars contained window boxes, some with cellophane bags also included. All master cartons in the trucks contained cellophane bags.

² Partial unloading, test packages removed.

For these tests Massachusetts-grown Early Black cranberries were packaged in 1-pound window boxes or in 1-pound cellophane bags; 24 of these small packages were packed in conventional fiberboard master cartons.

The mechanically refrigerated cars were loaded solid 6 rows wide and 5 or 6 layers high in all cars. In cars E and F the cartons were placed so that they formed a cross-wise offset load, having one continuous air channel lengthwise of the car, alternating in each layer along either side wall. No such continuous air channels were provided in cars G and H.

Each car had a compartment at one end housing a diesel engine-generator power plant which operated the refrigeration system. The thermostats were set at 35° F. The engines were started sometime before loading began and were operated continuously thereafter except in test 2, when the engines were cut off during loading.

To obtain commodity temperatures continuously from time of loading to time of unloading, recording thermometers were placed inside the test cartons located in the centerline of the cars at the top doorway, middle quarterlength, and bottom end positions at one end of the cars. Outside air temperatures, during transit, were obtained with a similar recorder placed underneath the car.

The two mechanically refrigerated trucks were loaded solid 5 cartons wide (3 wide in the "nose"), and 6 or 9 high. There were two continuous lengthwise air channels, about 4 inches wide, in each layer at alternate sides of the truck. One channel was formed by the offset position of the cartons, with the first row of each layer away from the side wall, and the other channel between the first row and the adjacent cartons in the second row. Spaces of 7 and 8 inches between the loads and the rear doors in both trucks permitted some air circulation through the longitudinal channels in the loads.

Truck C, shipped with a warm load, was equipped with a gasoline-driven mechanical refrigeration unit. The thermostat was set at 35° F. The walls, floor, and ceiling had 4 inches of insulation. This truck had a side door and a rear door, but no vents. There was a permanent metal floor rack, formed by grooves in the aluminum floor, measuring 1-3/16 inches high by 3/4 inch wide. This truck contained no flues, side wall slats, or ceiling duct to deliver cold air.

Truck D, shipped with a precooled load, was equipped with a propane gas-driven refrigeration unit. It was believed to have 6 inches of insulation. The improperly calibrated thermostat was set at 47° F., but the cooling unit came on at 39° and shut off at 35° F. Four canvas ducts, 7 inches wide and 7 inches deep at the ceiling, extending from the refrigeration unit at the front end to about the center of the truck, directed the cold air to the rear doorway area. This truck had no side doors, and no floor racks or flues. Four 1/2-inch by 3-inch wooden longitudinal slats spaced 12-1/4 inches apart, on each side wall, extended 55 inches above the floor.

For continuous temperatures of the commodity in transit, recording thermometers were placed in the top, middle, and bottom layers in cartons of the third stack from the end door. Test packages for examination at destination were removed from the middle layers in the two trucks.

Packaged fruit was inspected for decay and physiological breakdown at the time of shipment, and at various intervals after arrival at destination. Cranberries for inspection purposes in each test were comparable with each other but not with berries in the other tests.

RESULTS

Temperature reduction during precooling. --Figure 1 shows the results of the tests to precool prepackaged cranberries in master cartons and nonscreened (in the chaff) berries in field boxes to about 36°-40° before loading and shipping in mechanically refrigerated cars.

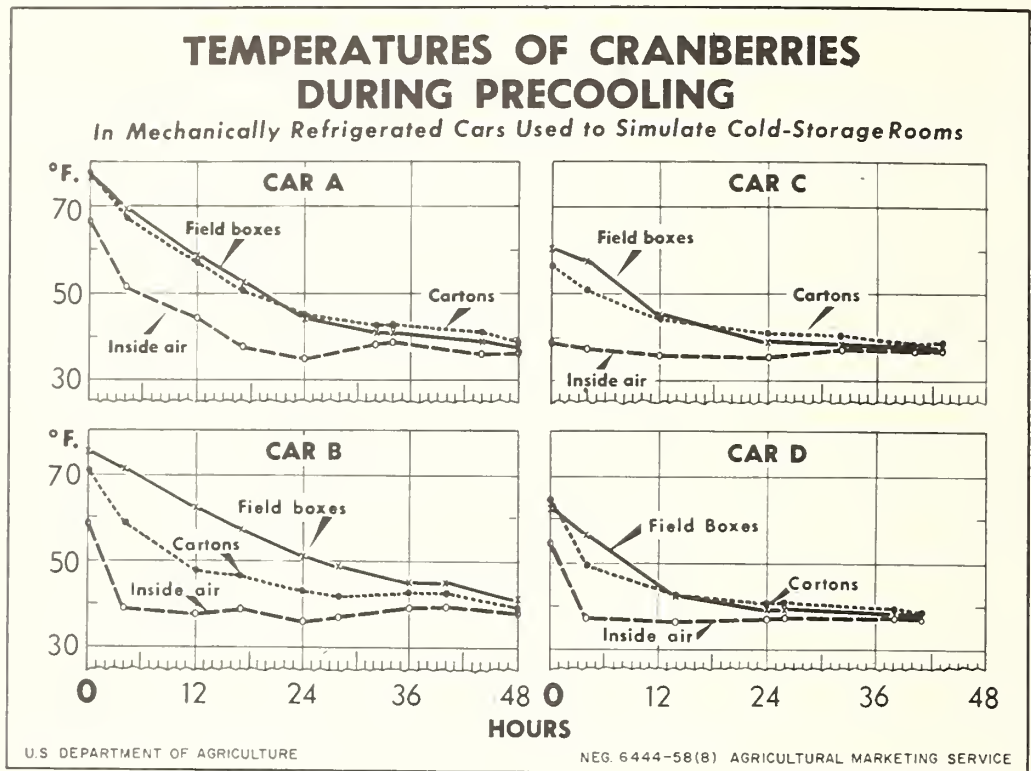


Figure 1

In the first test (cars A and B), the packaged berries were precooled from 74.3° to 43.9° in 24 hours and to 39° in 48 hours. The average temperature of the nonscreened berries in field boxes in this test was reduced in 48 hours from 76.3° to 39.7°. In some tests the field boxes cooled somewhat more slowly than the cartons, especially in car B, but this may have been due to inadvertently placing thermocouples in the center of a window box adjacent to the sides of the cartons; whereas, in the somewhat larger field boxes the thermocouples were placed in the center.

In the second precooling test (cars C and D), the initial temperatures of the berries were lower. Temperatures of the packaged berries dropped from an average of 60.3° to 40.6° F. during 24 hours of precooling; they dropped about 1.5 degrees in the remaining approximate 18 hours of precooling. Nonscreened berries in field boxes cooled at about the same rate as the packaged berries in this test. The outside air temperature during precooling ranged from 56° to 67°.

Figure 2 shows average temperatures of the prepackaged fruit in the two trucks (A and B) used as simulated cold-storage rooms. In truck A the average initial temperature of 75.5° was reduced to 39.5° in 24 hours and to 37° in 45 hours, a total reduction of 38.5 degrees. In truck B the average was reduced from 73.2° to 56.3° in 24 hours and to 44° in 48 hours; the total reduction was 29.2 degrees. In the field boxes the average reduction in temperature during 45 and 48 hours of precooling was 39.6 degrees and

31.8 degrees from initial temperatures of 75.3° and 77.5°. The slower cooling rate in truck B was probably due to its poor condition (such as defective sheathing, and poor closure of door and vents). The cooling rate for truck A was quite satisfactory.

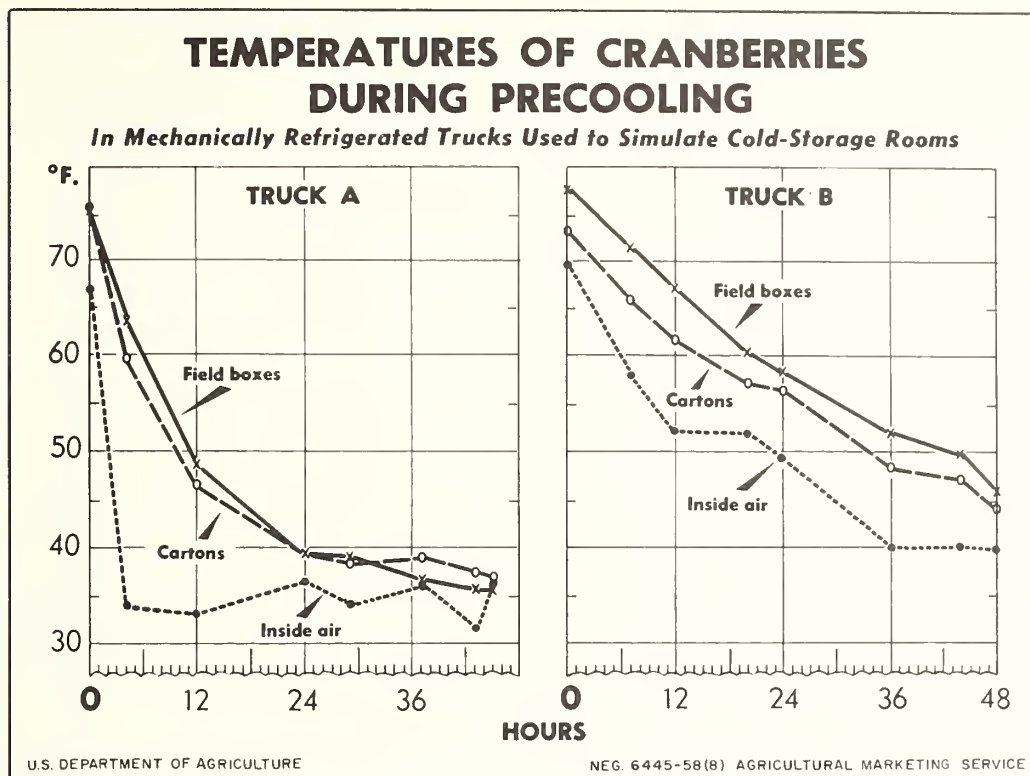


Figure 2

Temperature reduction in transit. --In the first rail test, the average initial shipping temperature of the berries in the precooled load was 44.3° F; it was further reduced in transit to 40° (table 2, fig. 3).

In the second rail test, the starting temperatures in the precooled load averaged 40.3°. In transit, this was reduced to 36° F. (table 3, fig. 3).

The starting temperatures for the two nonprecooled rail test loads averaged 67.7° and 64.7°. These were lowered to an average of 39.7° and 37° by the end of the trip. In transit, the commodity temperatures averaged 46.5° and 42.6° F. for the trip as a whole. As shown in figure 3, about 5 to 6 days were required for the average temperatures of the nonprecooled berries in these two cars to reach the starting temperatures of the berries in similar positions in the precooled loads. The greatest temperature differences between the precooled and the nonprecooled loads were found in the middle layers, where berry temperatures were 5 to 21 degrees higher in the nonprecooled loads for the first 7 days after loading (tables 2 and 3). However, during the latter part of the transit period the temperatures were close to those of the middle layers in the precooled shipments.

TABLE 2.--Temperatures of Early Black cranberries in mechanically refrigerated cars in transit from Onset, Mass., to Los Angeles, Calif., 1957 (test 1)

Car, treatment, and location of thermometer	At start of loading	Days after loading ¹														Average for trip
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
E precooled):	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Top (doorway)-----	42	39	39	39	39	38	39	38	38	38	38	38	38	38	38	38.6
Middle (quarterlength)-----	47	43	43	43	43	43	44	44	44	44	45	45	45	45	45	44.2
Bottom (end)-----	44	40	39	38	38	38	38	38	38	38	38	38	38	37	37	38.5
F nonprecooled):																
Top (doorway)-----	67	59	50	44	42	41	40	39	39	39	38	37	37	37	--	43.5
Middle (quarterlength)-----	66	62	64	64	59	55	54	51	50	48	48	47	47	46	--	54.4
Bottom (end)-----	70	54	44	40	39	39	39	38	38	38	37	36	36	36	--	41.7
Outside air: ²																
Maximum-----	--	73	77	80	73	68	68	80	70	85	86	92	91	89	--	--
Minimum-----	--	52	71	68	58	43	51	47	47	40	50	64	56	62	--	--

¹ All temperatures taken in centerline of car with recording thermometers.

² Thermometer attached on the outside, underneath car.

TABLE 3.--Temperatures of Early Black cranberries in mechanically refrigerated cars in transit from Wareham, Mass., to Los Angeles, Calif., 1957 (test 2)

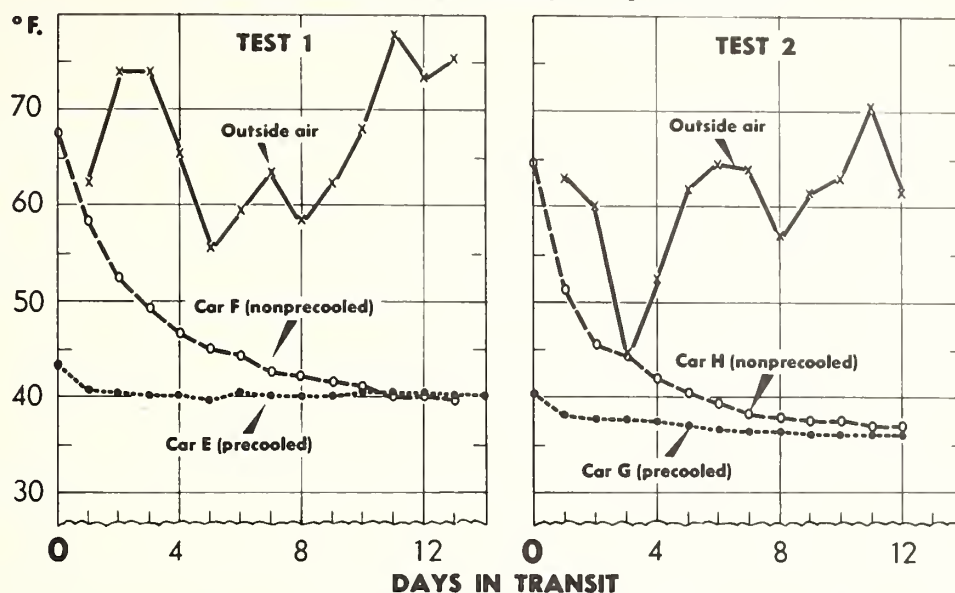
Car, treatment, and location of thermometer	At start of loading	Days after loading ¹												Average for trip
		1	2	3	4	5	6	7	8	9	10	11	12	
G (precooled):	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Top (doorway)-----	40	38	38	38	38	38	38	37	37	36	36	36	36	37.4
Middle (quarterlength)-----	42	40	39	39	38	37	36	36	36	36	36	36	36	37.5
Bottom (end)-----	39	36	36	36	36	36	36	36	36	36	36	36	36	36.2
H (nonprecooled):														
Top (doorway)-----	65	52	44	42	42	38	38	38	38	38	38	36	36	41.9
Middle (quarterlength)-----	64	58	55	54	48	47	44	41	40	39	39	39	39	46.7
Bottom (end)-----	65	44	38	37	36	36	36	36	36	36	36	36	36	39.1
Outside air: ²														
Maximum-----	--	70	79	56	63	68	73	78	72	79	73	73	64	--
Minimum-----	--	56	41	33	42	54	56	50	42	44	53	68	59	--

¹ All temperatures taken in centerline of car with recording thermometers.

² Thermometer attached on the outside, underneath car.

TEMPERATURES OF PRECOOLED AND NONPRECOOLED CRANBERRIES

During Transit in Mechanically Refrigerated Cars



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Figure 3

In the trucks, the starting temperatures of the precooled test cartons averaged 47.7° F. (table 4). In transit the temperatures of the top and middle layers fell slightly, but there was a small rise in the bottom layer, indicating the need of floor racks for better air circulation. The starting temperatures in the nonprecooled truck averaged 73.7° F. During the 24-hour transit period the average was reduced by 23.7 degrees, but it was still 50° F. at arrival. This was several degrees higher than the precooled load (table 4, fig. 4).

TABLE 4.--Temperatures of Early Black cranberries in mechanically refrigerated trucks in transit from Onset, Mass., to Chicago, Ill., 1957 (test 3)

Truck, treatment, and location of thermometer ¹	At start of loading	Hours after loading ¹				At unloading ²	Average
		6	12	18	24		
C (nonprecooled):	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Top layer-----	74	68	52	46	41	41	53.7
Middle layer-----	73	70	68	64	62	58	65.8
Bottom layer-----	74	68	59	52	47	41	56.8
D (precooled):							
Top layer-----	45	44	42	41	41	37	41.7
Middle layer-----	50	48	47	47	46	44	47.0
Bottom layer-----	48	49	50	52	53	51	50.5

¹ The recording thermometer temperatures were taken in the rear of the truck, third stack from end door.

² Truck C was unloaded Sept. 20; truck D was held over to Sept. 23. Both trucks were loaded and shipped Sept. 19.

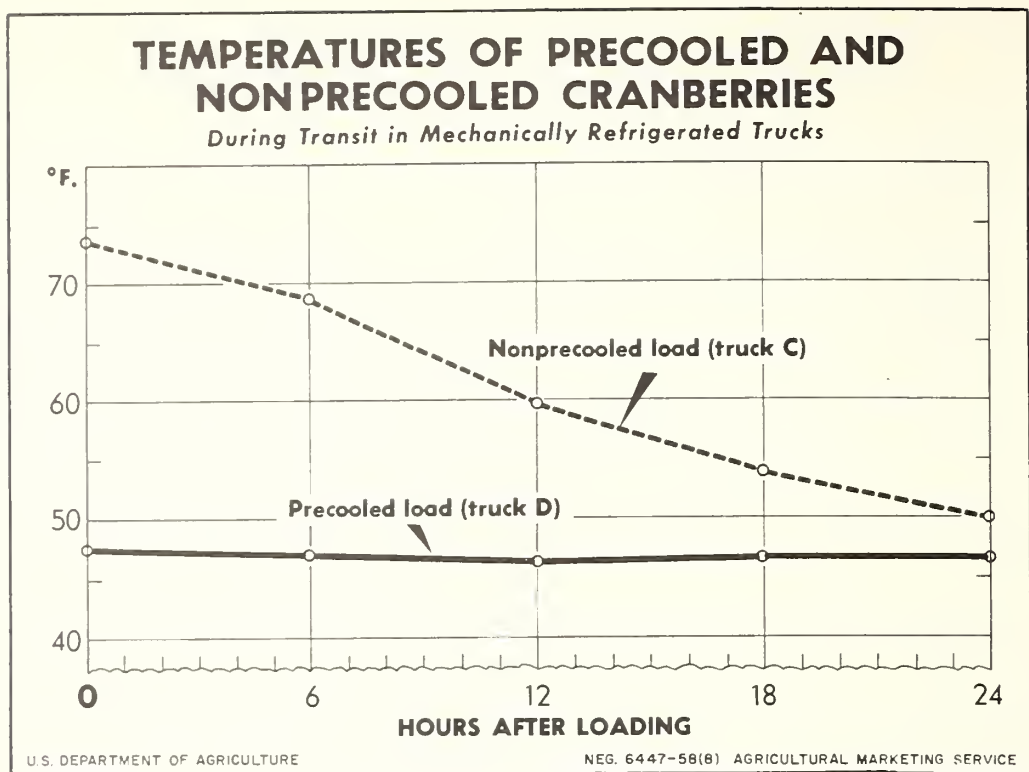


Figure 4

Condition of the loads. --The loads in cars and trucks arrived in generally good condition. Some tilting of the packages in the top layer was noted in most of the cars. A 21-inch shift from one end towards the center caused no breakage in car G. The shift was probably due to longitudinal slack in the load.

Decay and physiological breakdown. --In the first pair of cars (test 1), freshly harvested cranberries were used. About twice as much decay was found in the nonprecooled as in the precooled cranberries. For the precooled lots, decay averaged 1.6 percent at arrival at Los Angeles after a transit period of 14 days, 4.8 percent after holding at 70° F. for 7 days, and 7.3 percent after 14 additional days at 70°. Comparable decay percentages for the nonprecooled berries were 3.4, 11.1, and 14.7.

The second pair of cars (test 2), which contained cranberries that had been held in common storage for 3 to 4 weeks before packaging, were shipped during cooler weather than the cars in test 1 (see tables 2 and 3). Practically no difference was found in the amounts of decay between the precooled and the nonprecooled fruit on arrival or during subsequent holding periods (table 5). During the 3 to 4 weeks of storage some incipient field infection probably developed into rots which were milled out (screened) before packaging. This may account for almost the same incidence of decay in the precooled and nonprecooled berries.

In the truck shipments, which were made with freshly harvested cranberries, slightly more decay was found in the nonprecooled lots than in the precooled berries (table 5) even though the precooled shipment was unloaded 3 days later than the nonprecooled shipment.

TABLE 5.--Effect of precooling on decay and breakdown of prepackaged cranberries after indicated holding periods¹

Time of inspection	Car E (precooled)		Car F (nonprecooled)		Car G (precooled)		Car H (nonprecooled)		Truck C ³ (nonprecooled)	Truck D ³ (precooled)
	Decay	Physiological break-down ²	Decay	Physiological break-down ²	Decay	Physiological break-down ²	Decay	Physiological break-down ²	Decay	Decay
At shipping point (when packed)-----	Percent 0.6	Percent 0.2	Percent 0.6	Percent 0.2	Percent 1.4	Percent 0.0	Percent 1.4	Percent 0.0	Percent 1.2	Percent 1.2
At destination (on arrival)-----	1.6	0.6	3.4	1.8	2.4	0.4	2.4	1.0	8.0	6.8
After holding at 70°										
1 week-----	4.8	3.6	11.1	6.7	4.5	2.2	4.6	1.8	28.4	21.5
2 weeks-----	7.3	6.7	14.7	6.2	9.6	10.0	9.3	7.3	31.8	24.2
After holding at 45°										
2 weeks-----	2.9	2.6	5.7	4.3	3.4	1.1	3.4	1.2	--	--

¹ Result for each holding period is a composite of top doorway, middle quarterlength, and bottom end layer positions in cars, and middle layer only in trucks. The berries were in 1-lb. window boxes in cars, and 1-lb. cellophane bags in trucks. Percentages are based on 5 to 14 lb.

² Most physiological breakdown was slight and of little commercial significance.

³ Test fruit for both trucks was packaged on Sept. 16. Truck C was unloaded Sept. 20, truck D was unloaded on Sept. 23.

In tests 1 and 2, there was slightly less physiological breakdown in the precooled cranberries (table 5). In the truck shipments (test 3) no appreciable physiological breakdown was observed on arrival and after holding.

Kaufman, Jacob, 1907—

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